

## TURBOGENERATOR POWER CONTROL SYSTEM

### TECHNICAL FIELD

This invention relates to the general field of turbogenerator controls and more particularly to an improved high speed turbogenerator control system having variable frequency output power which provides electrical power to motors which have power requirements that normally vary in a repetitive manner over time.

### BACKGROUND OF THE INVENTION

There are many industrial and commercial applications that utilize electrical motors to produce repetitive axial motions. The electrical motor's rotary motion can be converted into axial motion by any number of mechanisms such as cams, cranks, scotch yokes, or cable drums just to name a few. In any such application, the electrical power requirement of the motor is inherently variable and is cyclically locked to the repetitive axial motion. The motor power in these applications varies both due to inertial effects (the need to accelerate and decelerate the axially moving components of the system and the need to accelerate and decelerate the rotationally moving components of the system) and due to the work effects (changes in the work performed by the axially moving components as a function of their axial position and velocity). The magnitude of the motor power variation with time can be many times the average power requirement of the motor. Both the inertial effects and the work effects can cause the motor to function as a generator which produces electrical power at various times in the system's cyclical motion.

greater than the maximum safe temperature 275, the proportional integral control 278 establishes a recommended frequency increase signal 218 (limited in limiter 280) in the low frequency load inverter frequency and hence the pump-jack oil well speed that should eliminate the over temperature.

5       The instantaneous frequency input signal 243 is provided to frequency control 300 which also receives the pump frequency signal from each pump-jack oil well controlled by the control system, shown for purposes of illustration only as three, namely signals 301, 302 and 303.

10       The frequency control signal 306 from the historical frequency control 300 is provided to comparator or summer 282 which also receives signal 269 and both of the two inverter frequency reduction signals 279 and 218. The error signal 291 from summer 282 is provided to limiter 289 before going to the inverter 144. This limited error signal controls the frequency of the inverter 144 and provides a frequency limit signal 243 to both comparator 242 and to the look up table 290 which computes the inverter output voltage.

15       Figure 7 is a functional block diagram of the historical frequency control 300 of the power control system illustrating how the low frequency load inverter frequency historical average, and current requirements are computed for three oil wells. Historical frequency control 300 includes a frequency computer for each pump-jack oil well which is being supplied with electrical power. Each of these frequency computers, shown for purposes of illustration as three, namely 350, 360, and 370 require a once per pump cycle signal 301, 302, and 303, respectively, from the associated  
20       pump-jack oil well. Each frequency computer determines the low frequency load inverter's frequency that it prefers at any point in time which should cause the power requirements of its oil well to be nearly constant over a complete pumping cycle. To compute the low frequency inverter's frequency at any point in time that will achieve nearly constant power requirements over

time for all oil wells operating together, averaging block 380 receives signals 330, 331, and 332 from frequency computers 350, 360 and 370, respectively, and computes one best compromise frequency for the low frequency load inverter and all the induction motors of all the oil wells.

When more than one oil well is being powered by a turbogenerator, the power requirements of each induction motor do not need to be held constant as long as the sum of the requirements of all of the induction motors is a constant. Thus, there is, at any instant, a single frequency at which all induction motors (and thus the low frequency load inverter) can operate which will achieve a constant power requirement over time for the turbogenerator/motor. The averaging block 380 computes this frequency and outputs its value 306 to summer 282.

Each of the historical frequency computers 350, 360, and 370 requires a pulse signal 304 that is frequency and phase locked to the inverter frequency (six times output frequency is preferred) derived from the low frequency inverter.

Figure 8 is a detailed functional block diagram of one of the historical frequency computers showing and how the low frequency load inverter frequency requirements are computed for one oil well (prior to averaging for additional oil wells) based on historical data. While specifically illustrating historical frequency computer 350, it is equally applicable to historical frequency computers 360 and 370. For historical frequency computer 350, once per oil well pumping cycle signal 301 is inputted to pulse generator 310 which convert the analog pulse to a digital pulse. This signal pulse is then delayed approximately 50 nanoseconds and then used as a reset command input to inverter pulse totalizer register 313 and motor slip totalizer register 317. This delay is accomplished in delays 312.

This signal pulse from pulse generator 310 is also used undelayed to command an update of last value registers 314 and 318 and delayed to shift data in shift registries 315 and 319. This